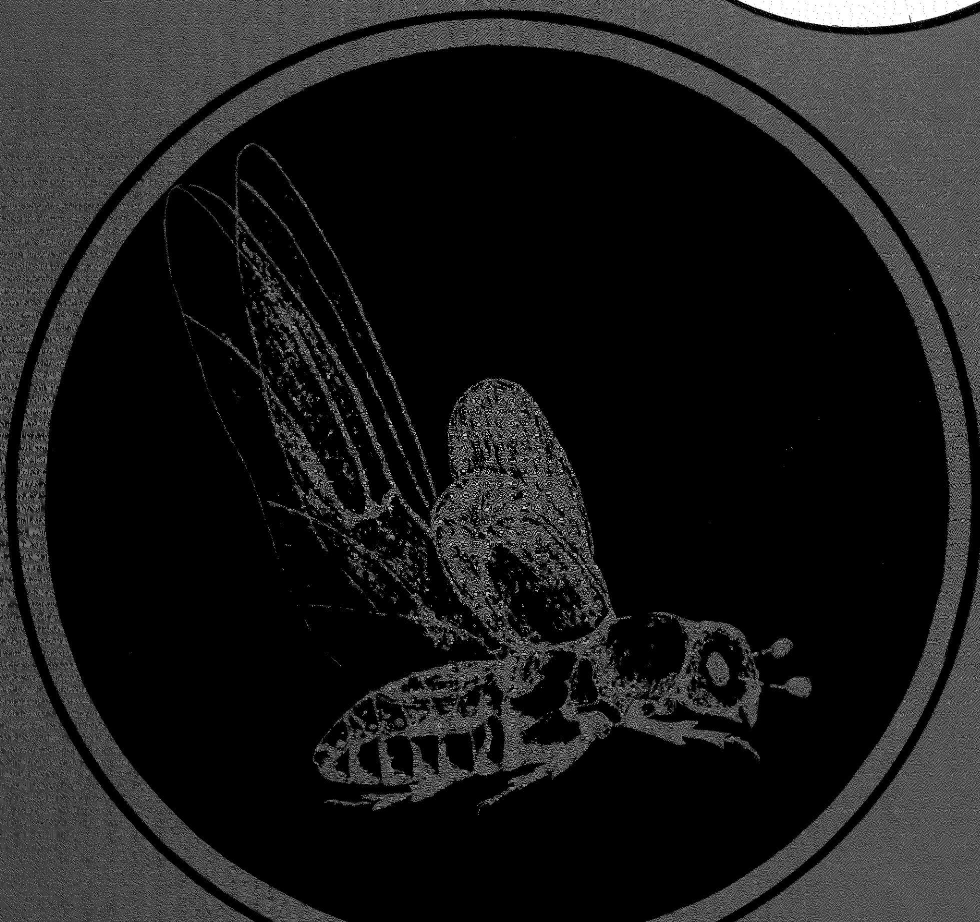
Forest Insect And Disease Management

3430

BIOLOGICAL EVALUATION R-10-83-1
FOLLOWUP
SURVEY OF AMBROSIA BEETLES AND DETERIORATION IN BLOWDOWN

YAKUTAT, ALASKA

JANUARY 1983



U.S. Department of Agriculture
State and Private Forestry

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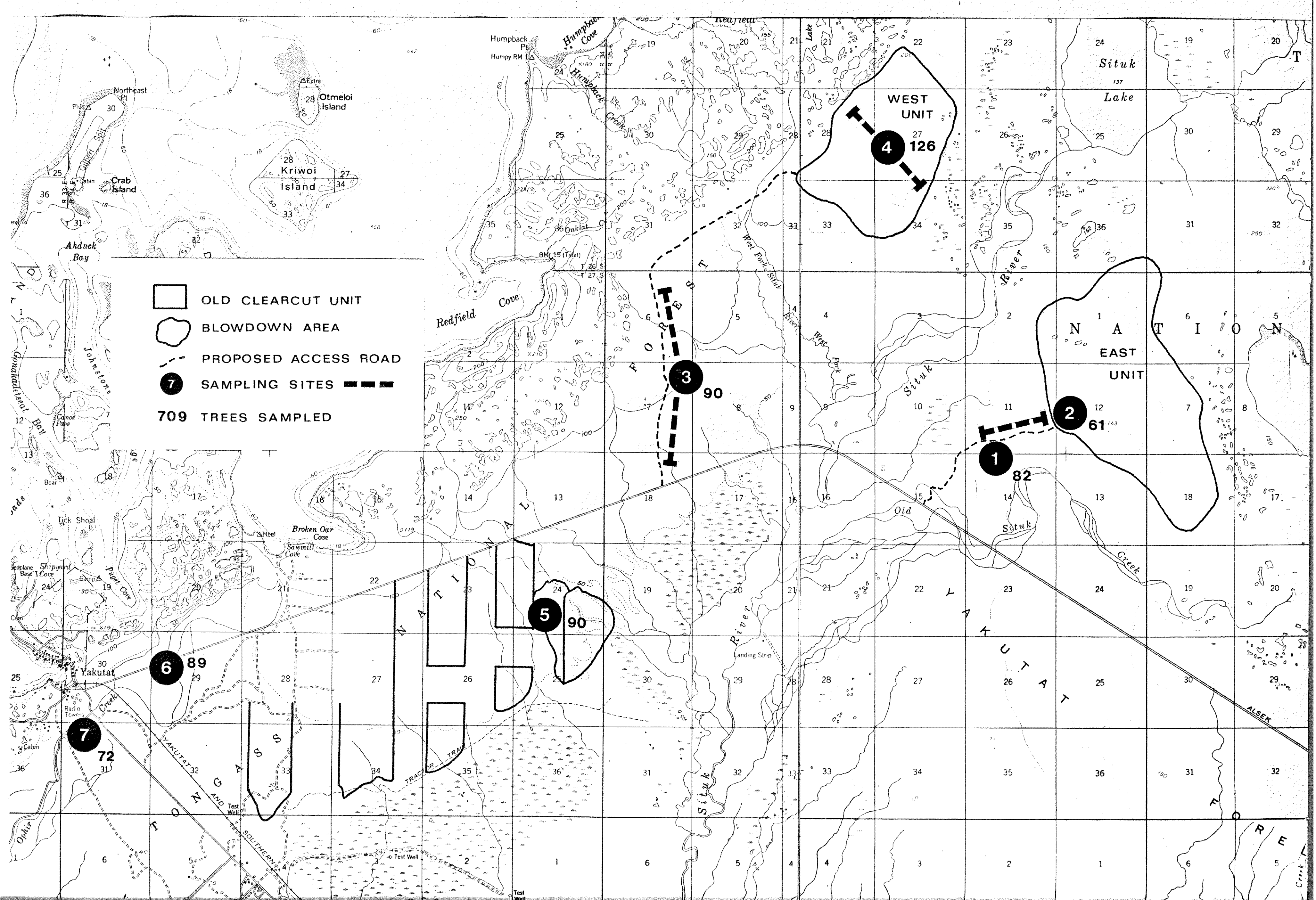
INTRODUCTION

A severe windstorm on January 18, 1981 caused extensive damage to timber stands throughout the Yakutat forelands in the northern part of Southeast Alaska. Approximately 100 million board feet of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) were blown down on more than 3500 acres (USDA Forest Service, 1981). Wind damage occurred from Dangerous River westward to Redfield Lake, but the greatest concentration was in two areas on either side of the Situk River north of Forest Highway 10 (Figure 1).

About two-thirds of the blowdown occurred on lands administered by the U.S. Forest Service, with the remainder on adjoining State and native lands. The Forest Service proposed a salvage sale and evaluated several harvesting alternatives for major portions of the blowdown. An environmental assessment report which concentrates on the two major areas of blowdown shown in Figure 1 was prepared in May 1981. The alternative preferred by the U.S. Forest Service calls for harvest of 40 MMBF from the affected areas, three-fourths of which is windthrown material. Salvage harvesting has also been planned for State and native lands, and is already underway on some native holdings.

Forest Pest Management personnel have been involved in identifying the potential for adverse effects from insects and diseases, including wood degradation and possible bark beetle outbreaks in standing timber. In August 1981, a field survey was conducted to examine the attack levels of bark and ambrosia beetles in the Yakutat windthow. The results from this initial survey indicated that insect populations were low, with bark beetles and ambrosia beetles occurring in only 3% and 7% of the down material, respectively. It was noted at that time, however, that much of the windthrown material was still green, and possibly too fresh to be attacked by ambrosia beetles in the first year. Thus, another survey was carried out in August 1982, to evaluate changes in insect populations and additional deterioration of the windthown spruce and hemlock. Results of that followup evaluation are presented in this report.


OLD CLEARCUT UNIT
BLOWDOWN AREA
PROPOSED ACCESS ROAD
7 SAMPLING SITES
709 TREES SAMPLED
WEST UNIT
EAST UNIT
4 126
3 90
2 61
1 82
5 90
6 89
7 72
Situk Lake
Otmeloi Island
Kriwoi Island
Crab Island
Humpback Pt
Humpback Cove
Redfield Cove
Broken Oar Cove
Yakutat
Ahdnck Bay
TONGASS NATIONAL FOREST
YAKUTAT FORE
Old Situk Creek
Situk River
West Fork Situk River
Landing Strip
Tick Shoal
Sawmill Cove
Radio Towers
Test Well
YAKUTAT AND SOUTHERN
ALSEK

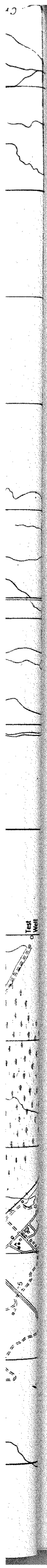


Figure 1. Major blowdown areas and location of sampling sites for assessment of ambrosia beetle populations and deterioration, August 1982. (Numbers beside site locations indicate total number of trees examined).

METHODS

Selection of sampling sites

All five sampling sites from the August 1981 survey were revisited in 1982. These sites reflected the diverse age classes and diameters affected by the windstorm, and provided a good cross-section of the conditions present in the blowdown area. In addition, two new sites were sampled at the request of the State of Alaska Division of Forestry. Locations of all seven sampling sites are shown in Figure 1, and are briefly described below:

Site 1. P-line of proposed access road to East blowdown unit. Sampling was done between survey station markers 128+00 and 150+30 near edge of cutting boundary. Stands consist of young, small diameter spruce, with heavily shaded windthrows scattered throughout. 82 trees were examined.

Site 2. Area of nearly complete blowdown within East Unit. All down trees of small diameter, mostly spruce, with little or no shading. 61 trees examined.

Site 3. P-line of proposed access road to West blowdown unit. Sampling was done from three chains north of FH10 to survey station marker 6505. Old-growth spruce-hemlock stands with several large diameter windthrows. Blowdown scattered, with heavy shade from residual stand. 90 trees examined.

Site 4. Medium-sized spruce-hemlock stands inside West Unit with moderate to heavy blowdown and little shading from residual trees. 126 trees examined.

Site 5. Leave strip between two old clearcut units on Kwaan Native Corporation land. Stands composed of large diameter spruce and smaller hemlocks. Blowdown pattern variable; fairly extensive throughout most of the leave strip, but scattered along the western edge. 90 trees examined along western edge of the blowdown where shading from residual stand was greatest.

Site 6. State Unit #2. Large diameter spruce and smaller hemlocks in roadside leave strip near city dump. Blowdown in this unit was fairly extensive, with few residuals remaining. 89 trees sampled on south side of Forest Highway 10.

Site 7. State Unit #3. Large diameter spruce and hemlock stands in leave strip near Ophir Creek. Blowdown fairly extensive, with little shading. 72 trees examined.

Survey procedure

At each survey site, a transect line was established in order to select windthrown trees for sampling. Within the blowdown areas, the transects consisted of predetermined compass lines, and every tree lying across the line was examined. In sampling sites 1 and 3, the access road P-lines were used as the transects, and every windthrow within one chain of the P-line was examined. For sites 1, 3, and 4, the hatched lines in Figure 1 indicate the general location of sampling transects.

On each sampled tree, the breast-height diameter was estimated to the nearest inch. Periodically, sample trees were measured with a D-tape to verify the diameter estimates. Crowns of the windthrows were described in terms of foliage color and percent needle retention using a numerical index from 0 to 4 (0 = no crown remaining; 1 = less than 1/3 of crown remaining and foliage mostly brown; 2 = 1/3 of crown remaining with foliage green and brown in equal proportions; 3 = less than half of crown remaining with foliage green; 4 = greater than 50% of crown remaining, foliage almost entirely green). The form of windthrow was also noted for each sample tree. Although most windthrown trees had been uprooted, blowdown through stem breakage was recorded whenever applicable. The degree of shading provided by the residual stand was recorded in general terms (greater or less than 50% canopy remaining around the windthrow). The bole of each tree was examined closely for presence of beetle frass or galleries, and the outer sapwood was inspected for deterioration.

For trees with evidence of ambrosia beetles, the severity of attack was noted and classified as Light (1-20 attacks per square foot), Moderate (21-50 attacks per square foot), or Heavy (51+ attacks per square foot). In order to facilitate the determination of attack intensity, a 6 x 6" bark sample was removed with a hatchet and the beetle entry holes were counted on the exposed section of sapwood. Ambrosia beetle galleries were dissected in order to determine if the attacks had occurred in 1981 or 1982. The presence of beetle brood in the galleries served as an indicator of a recent (1982) attack.

The incidence of bark beetles (spruce beetles and secondary beetles) was recorded, but brood data were not collected.

In addition to the 610 trees examined intensively, another 99 windthrows in the West Unit were casually inspected for presence of ambrosia beetle frass on the bole.

RESULTS AND DISCUSSION

Characteristics of the windthrown material

The number of down trees sampled and their characteristics are shown in Table 1 for each sampling site. Since no attempt was made to resample the trees examined in 1981, some of the characteristics of the sampling areas were slightly different from the previous year. 610 windthrows were examined in August 1982, including 535 Sitka spruce and 75 western hemlock.

TABLE 1

Characteristics of down trees examined for ambrosia beetles in Yakutat Forelands windthrow. August 1982.

SAMPLING SITE		TREES SP	TREES #	DBH	CROWN [1]		DAMAGE [2] WT	DAMAGE [2] BR	%SHADING -50	%SHADING 50+
East Unit P-line	1	S	82	14 ± 4"	2.4	2.4	80	2	82	0
		H	0							
East Unit Interior	2	S	59	16 ± 5"	3.1	3.1	59	0	0	59
		H	2	17 ± 2"	2.5		2	0	0	2
West Unit P-line	3	S	76	25 ± 12"	1.5	1.6	67	9	62	14
		H	14	16 ± 8"	2.1		12	2	14	0
West Unit Interior	4	S	108	17 ± 5"	2.1	2.1	101	7	18	90
		H	18	19 ± 8"	1.9		16	2	9	9
Kwaan	5	S	82	24 ± 10"	2.0	2.1	74	8	35	47
		H	8	11 ± 3"	3.0		8	0	2	6
State Unit #2	6	S	66	22 ± 13"	2.7	2.6	65	1	0	66
		H	23	12 ± 5"	2.3		17	3	0	23
State Unit #3	7	S	62	23 ± 10"	2.3	2.3	61	1	0	62
		H	10	16 ± 10"	2.4		8	0	0	10
TOTAL			610			2.3	570	35	222	388

[1] Numbers indicate average crown for all windthrows in the sampling site.

[2] WT = windthrown or uprooted trees, BR = wind breakage or "snap-off."

Sitka spruce represented at least 80% of the windthrown material in each sampling area except State Unit #2 (Site 6) where 26% of the windthrows were western hemlock. Trees examined in the East Unit (Sites 1 and 2) were of relatively small diameters indicative of younger stands in that area. Windthrows in the West Unit (Site 4) were slightly larger, as were the sample trees in the two State Units (Sites 6 and 7). The largest trees sampled were on Kwaan land (Site 5) and along the West Unit P-line (Site 3) (Table 1).

Windthrow by uprooting (94%) was far more common than stem breakage (6%). The greatest amount of stem breakage occurred in sampling sites 3, 4, and 5 where 9% of the windthrows had snapped off above ground. Slightly more than one-third of the windthrows sampled in 1982 were shaded, with nearly two-thirds in the open.

In 1982, the crown color and condition were far more variable than in the previous year. In 1981, 94% of all crowns were totally green with full needle retention, but in 1982, crowns ranged from nearly full and green, to foliage totally absent. The average crown in 1982 still retained some green foliage, but over half of the needles were either brown or missing. A comparison of average crown indices from each sampling site showed that the greatest degree of crown deterioration was in the West Unit (Sites 3 and 4) and the Kwaan (Site 5). Very little foliage remained on these trees whereas the crowns on windthrows in the East Unit and State Unit #2 were in substantially better condition (Table 1).

<u>Incidence of ambrosia beetles and bark beetles</u>

Ambrosia beetle populations were much higher in 1982 than in the previous year. Whereas only 8% and 5% of the windthrown spruce and hemlock sustained ambrosia beetle attacks in 1981, the percentage of material infested in 1982 increased to 41% and 31%, respectively. Populations were highest along the West Unit P-line (Site 3) where 70 of 76 spruce were attacked (Figure 2). The lowest attack levels were noted in the East Unit (Sites 1 and 2) where 20% and 14% of the spruce were infested with ambrosia beetles. In the other four areas, populations were fairly uniform with 30 to 40% of the down material being attacked (Figure 2).

The attack intensity on infested material should be mentioned since it has economic importance. Beetle-caused degrade is a function of attack density and log quality; light attacks on high-quality logs cause severe loss, but heavy attacks in low quality wood are of little consequence (McBride and Kinghorn, 1960). Although nearly 40% of all windthrows in Yakutat were infested by ambrosia beetles, the average attack densities were generally fairly low. Table 2 shows the level of attacks on infested trees in each sampling site.

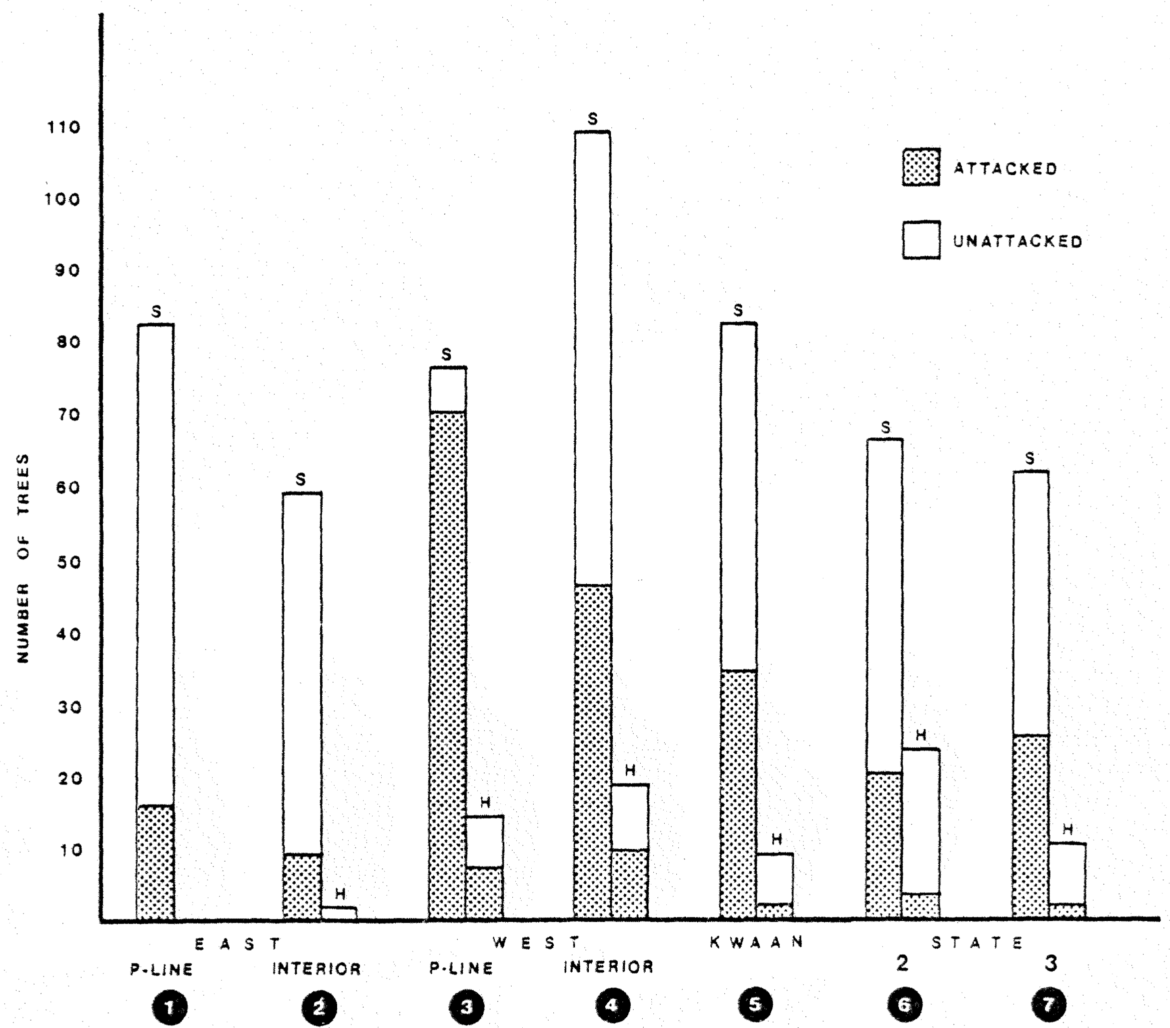


Figure 2. Incidence of striped ambrosia beetle, Trypodendron lineatum, on windthrown Sitka spruce (S) and western hemlock (H) at seven sampling sites in Yakutat Forelands. August, 1982.

Table 2

Attack intensity on windthrown trees infested
by striped ambrosia beetles. Yakutat, 1982.

Site	#Trees infested	LL	L	Attack L-M	Intensity M	M-H	H	HH	Ave
1	16	2	12	2					L
2	8	1	5	1			1		L-M
3	77	5	26	13	19	13	1		L-M
4	55	2	18	11	8	3	5	3	L-M
5	36	8	15	9	4				L
6	23	3	11	6	2	1			L-M
7	27	1	2	4	8	3			L-M
	242	22	99	46	41	20	7	3	

One-half of the infested trees sustained light or very light (LL) attacks by the ambrosia beetle, meaning that attack densities were less than 20 per square foot. The average attack intensities were lowest along the East Unit P-line (Site 1) and on Kwaan land (Site 5). Virtually all of the heavily attacked windthrows were found in the two West Unit sites, where the average attack densities were highest. A point of interest in Table 2 is that attack levels were variable within each sampling site and consequently, the amount of degrade will vary among infested stems within a given area.

A slight correlation was noted between ambrosia beetle attacks and the average diameters of windthrows. As shown in Table 3, the diameters of attacked trees were slightly larger than unattacked ones in some areas. This relationship is not well-defined, and does not imply that larger diameters are always more susceptible to ambrosia beetle attacks.

Table 3

Average diameters of spruce and hemlock as related to attacks by ambrosia beetles. Yakutat, August 1982.

Sampling Site	Species	Average Attacked	Diameters Unattacked
1	S	13 ± 3"	14 ± 4"
2	S	17 ± 5"	16 ± 5"
3	S	25 ± 12"	25 ± 7"
	H	19 ± 7"	13 ± 8"
4	S	20 ± 5"	15 ± 4"
	H	23 ± 7"	16 ± 7"
5	S	25 ± 9"	24 ± 10"
	H	9 ± 1"	12 ± 3"
6	S	30 ± 5"	18 ± 11"
	H	14 ± 7"	12 ± 5"
7	S	27 ± 11"	20 ± 9"
	H	33 ± 7"	12 ± 5"

The effect of shading did not seem to influence the level of ambrosia beetle attacks in 1982. In areas where more than 50% of the canopy still remained, attacks occurred on 42% of the windthrows. In unshaded areas, 35% of the windthrows were attacked.

In 1981, we noted that ambrosia beetle attacks were far more likely on broken than on uprooted material. Attacks in 1982 occurred on 63% of the broken stems we examined, and on 39% of all uprooted trees. Most of the attacks on broken stems were recent, suggesting that the accelerated rate of drying still had not put them beyond the susceptible stage by the 1982 flight season.

A strong relationship was noted between crown condition and incidence of ambrosia beetle attacks. On an area basis, attacks were highest where average crown condition was poorest (Site 3) and attacks were lowest where crowns were in the best condition (Site 1). This relationship is illustrated further in Figure 3, which shows the percent of trees attacked in each crown category. About 70% of all windthrows with a crown index of zero (crowns competely gone) were infested by ambrosia beetles. At the other extreme, where crowns were still green with nearly 50% of the needles retained (categories 3 and 4), less than 10% of the stems were attacked (Figure 3).

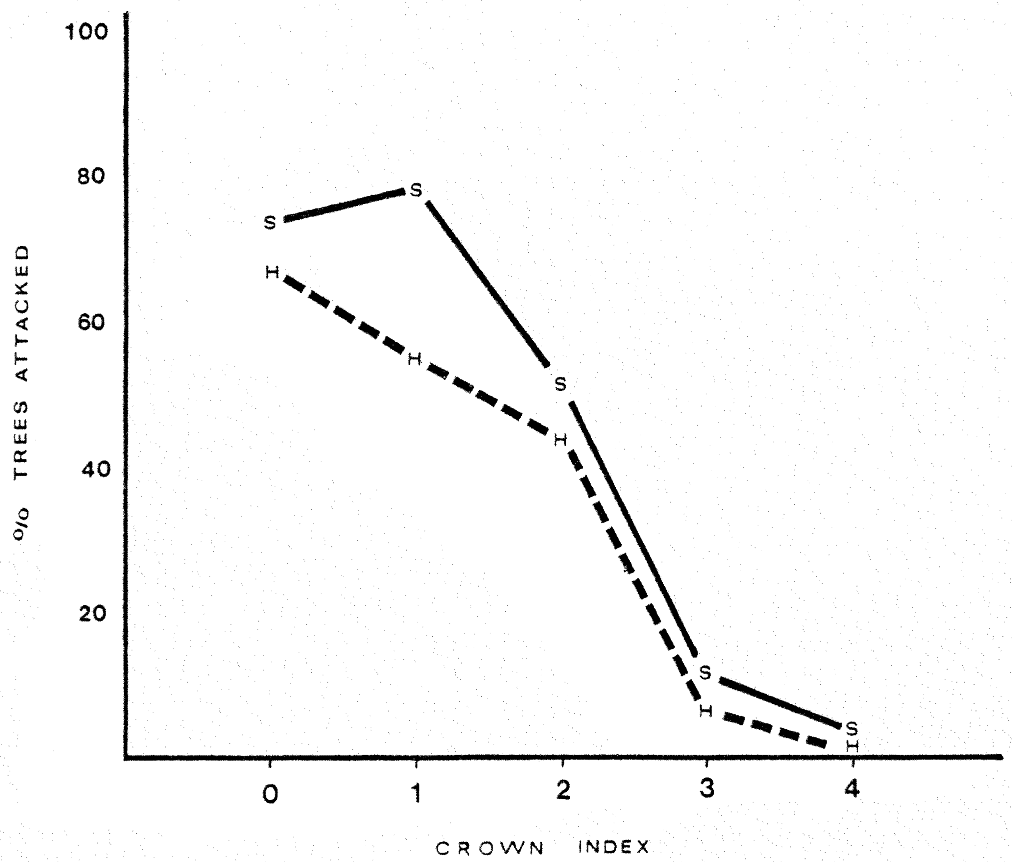


Figure 3. Percent of windthrows attacked by ambrosia beetles as related to crown condition. Yakutat, 1982. (Crown index of 0 indicates crown completely gone; 4 indicates green crown with greater than 50% of needles retained).

The crown condition can be used as an indicator of the moisture content of windthrown material, which is the most important determinant of susceptibility to ambrosia beetles. Windthrows with crown indices of 3 and 4 were probably too green to be attacked in 1982, but may become susceptible next season. Accordingly, the likelihood of an expanding infestation in 1983 may be greatest in areas which now have the highest crown indices.

Incidence of the spruce beetle also increased in 1982. Overall, 19% of the windthrown spruce were attacked, with considerable variability between sampling areas. Along the East Unit P-line, 46% of the spruce were attacked, while in the Kwaan site and State Unit #2, attacks occurred on only 2% and 5% of the windthrows, respectively. Elsewhere, spruce beetle attacks ranged from 14% to 25%. In virtually all cases, attack densities were light with low brood production. Outbreak potential for the spruce beetle remains very low, although some staining of the sapwood will develop in windthrows where attacks have occurred.

Influence of weather on ambrosia beetles during 1982

Weather records for the summer of 1982 indicate four distinct time periods when ambrosia beetle flights could have taken place in the Yakutat area. Maximum air temperatures exceeded 60°F on these occasions, with two to several successive days above the temperature threshold for beetle flight. The first flight of the season probably occurred on May 31 and June 1 when temperatures reached 63 and 69°F. No additional flight could have occurred until June 24, when temperatures were between 62 and 67°F for three consecutive days. Two other warm periods--in early July and mid-August--would also have permitted significant flights. Our observations of highly variable beetle development in the field support the idea of several flights during the 1982 season. In August, some beetle broods were fully mature and newly developed adults were emerging from the windthrows to seek hibernation sites. These beetles probably developed from early-season attacks (late May-early June). Most of the broods were in the pupal and callow adult stage, presumably the progeny of beetles attacking in July. In other cases, young larvae were found in recently formed galleries, and on some trees we noted fresh attacks less than a week old. This type of extended flight period may account for the fact that ambrosia beetle attacks were distributed lightly over a large number of windthrows. A short and concentrated flight would probably have resulted in heavier attacks on fewer trees.

Future population levels

The development of the ambrosia beetle problem in Yakutat has been a function of food supply and prevailing weather conditions. Although substantial material was on the ground in the summer of 1981, much of it was unsuitable for attack, and populations infesting the windthrows remained low for the first season. In 1982, more of the down material became susceptible and the weather patterns allowed for several small-scale beetle flights to occur throughout the summer.

As a result, light attacks occurred on numerous stems, predominantly in those areas where crown deterioration and drying of the windthrows was greatest. However, about 40% of all windthrows examined in 1982 were probably still too green to be attacked. Many of these trees may become infested in 1983 if they dry to the moisture level preferred by the beetles. Populations will likely increase in each area, but buildups may be greatest in areas such as the East Unit (Site 1 and 2) where a large proportion of the windthrows were still in good condition in 1982. Specific temperature patterns will determine when and how intensively additional attacks occur. If summer temperatures in 1983 are similar to 1982, then light to moderate attacks may spread out over a large number of currently uninfested windthrows. On the other hand, if one concentrated flight occurs over a short period, then heavy attacks on fewer stems may result.

Thus far, the pattern of ambrosia beetle buildup in Yakutat has been similar to a problem that developed on the Olympic Peninsula in the 1920s. Boyce (1929) found that beetle populations were low in the first summer following a severe windstorm, but increased substantially in the second year. He reported that after the third summer, nearly 75% of the windthrows were infested with ambrosia beetles. Although direct comparisons with Yakutat may not be appropriate, the point of concern is that the most dramatic population increases occurred in the second and third years after the blowdown. 1983, then, may be another critical year in terms of additional beetle buildup.

Stain and decay in blowdown

There are many variables which are affecting the rate of deterioration of the windthrown trees at Yakutat. Some of the known ones are species, percent sapwood, diameter, moisture content, temperature, presence or absence of prior decay, and insect attack. Interactions of these variables determine the rate of deterioration.

From past experience in Southeast Alaska, smaller diameter trees (less than 16" dbh) on the ground will be cull in approximately 12 years. These are trees with no decay prior to blowdown and no insect attack after blowdown. The rate of deterioration of the larger diameter trees will generally be slower under the same conditions. There are a number of reasons why the smaller trees deteriorate faster than the larger ones under identical conditions. Small diameter trees dry faster. The thinner bark dries out and slips more rapidly with the subsequent checking exposing a greater percentage (in comparison to a large diameter tree) of the wood to decay fungi. Insect attack, which degrades and innoculates the wood with stain and decay fungi, takes up a greater proportion of the cross-section of the small tree.

In an initially sound blowdown tree, the decay and stain fungi work inward from the surface. This inward attack is degrading or destroying the higher values of the tree first. Insect attack not only degrades this high value portion of the tree, but also speeds up its degradation by innoculating it with the stain and decay fungi.

The presence of stain organisms will be noted within a few weeks of insect attack. Stain fungi by themselves usually do not mechanically degrade the wood but do serve as a notice that decay fungi will soon be present. Trees, both large and small, with decay present before blowdown occurs, will deteriorate much faster than initially sound trees. This decay is usually a heartrot or root rot and works from the inside of the tree outward.

Hemlock will deteriorate faster than spruce. This greater rate of deterioration is probably due to the lack of resin compounds in hemlock in comparison to spruce.

Harvesting recommendations

Our recommendations for salvage depend somewhat on when the harvesting operations can be carried out. If windthrows can be salvaged in the spring of 1983, then we would recommend that areas with the lowest ambrosia beetle attacks be assigned the highest priority. These presently include the East Unit and State Unit #2. Considerable sound material still remains in all areas except the West P-line and prompt harvesting in those areas is encouraged. Beetle populations can be expected to increase next year in all areas, and new attacks are more likely to occur on stems presently uninfested than on windthrows which have already been attacked. Thus, the potential for extracting prime grade uninfested material will be further reduced by the end of the 1983 beetle flights. If harvesting is not done prior to 1984, it is doubtful that half of the down material will still be uninfested in any area. For salvage logging done later than 1983, we recommend that blowdown areas be resurveyed for beetle damage in 1983 and that priorities for harvest be reassigned, based on where the infestations have been lowest. However, if attack levels are found to be uniformly high in all areas after the 1983 flights, then salvage should be aimed at minimizing deterioration from fungi. This alternative would mean assigning highest priorities to areas with the smallest diameter trees, which have the highest rate of deterioration.

Certain precautions should be taken during the harvesting of standing timber which is included as part of the USFS sale. If standing trees are cut during the summer (prior to August), they should be removed promptly from the woods and yarded, utilized, or shipped as soon as possible. Any standing material cut in fall or early winter should be yarded by early spring before the next beetle flights occur. In yarding or sorting areas, logs should be separated into groups of infested and uninfested material. If the uninfested material is kept in dry storage during the summer months, periodic inspections should be in order to detect newly developing attacks. As beetle flights take place, some form of log protection will be required in order to avoid attacks on the yarded material. This protection may be achieved through the use of a water misting system (Richmond and Nijholt, 1972) or through the application of insecticides or pine oil (Nijholt, 1980).

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APPENDIX

BACKGROUND INFORMATION ON MAJOR INSECTS

The two most important insect species associated with windthrown spruce are the spruce beetle (*Dendroctonus rufipennis* (Kirby)) and the striped ambrosia beetle (*Trypodendron lineatum* (Olivier)). These insects have several biological characteristics in common. The flight period of both insects is strongly influenced by temperature, with 60-61°F. being the critical threshold for flight in both cases (Dyer, 1973; Chapman and Kinghorn, 1958). Beetle flight may vary dramatically from year to year, both in timing and intensity, depending on prevailing air temperature patterns during spring and summer. Dispersal flights may take place over several weeks in May or June (Schmid and Frye, 1977) but concentrated flights over a few hours may account for much of the log damage that occurs in any given year (Chapman and Nijholt, 1980).

For both insects, suitable host material consists of logging slash, stumps, and windthrows which have been on the ground for a short time. Susceptible host material for ambrosia beetles is four to nine month-old blowdown (Dyer and Chapman, 1965) and for spruce beetles, blowdown less than one year old. If windthrown spruce maintains root contact and does not desiccate, it may still be suitable for spruce beetle attack in the second year (Schmid and Frye, 1977). In host selection, the effect of direct sunlight is probably more important than diameter of the windthrown material (Schmid and Frye, 1977. Spruce beetles show a strong preference for shaded trees (Massey and Wygant, 1954). Shading is not as important for ambrosia beetles, and attacks may occur wherever the moisture content of host material is appropriate. Under most conditions, available host material for spruce and ambrosia beetles is scarce, and populations are limted by the lack of suitable breeding sites. However, in areas with active logging or with a history of periodic wind damage, populations may be high and can cause extensive damage following only subtle changes in conditions.

Another important similarity between bark and ambrosia beetles is their reliance on aggregating attractants, or pheromones, in locating and attacking their host material. Beetle attacks are non-random and tend to be concentrated on individual logs so that infested material is easily identified in the field. Both attack densities and the proportion of material under attack are good indicators of population levels.

Some dissimilarities between ambrosia and spruce beetles have important management implications. Spruce beetles are most likely to inflict damage on residual stands where trees are slow-growing, of large diameter, with heavily shaded windthrows scattered throughout. Rapid utilization of infested material is the most acceptable management method for reducing overall spruce beetle risk. In this way, beetle populations are reduced during salvage. Ambrosia beetles can accelerate log deterioration by tunnelling in the sapwood. Damage is thus most severe in small, rapidly growing trees with a high proportion of their volume in sapwood. Since ambrosia beetles overwinter in forest duff rather than in windthrows, salvage of infested material between fall and spring does not reduce the beetle populations. Harvesting should be aimed at unaffected material first in order to remove potential food source for the overwintering beetles.